

Estimating the Impact of the Balassa-Samuelson Effect in Transition Economies

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October 2003

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Founded in 1963 by two prominent Austrians living in exile – the sociologist Paul F. Lazarsfeld and the economist Oskar Morgenstern – with the financial support from the Ford Foundation, the Austrian Federal Ministry of Education and the City of Vienna, the Institute for Advanced Studies (IHS) is the first institution for postgraduate education and research in economics and the social sciences in Austria. The **Economics Series** presents research done at the Department of Economics and Finance and aims to share “work in progress” in a timely way before formal publication. As usual, authors bear full responsibility for the content of their contributions.

Das Institut für Höhere Studien (IHS) wurde im Jahr 1963 von zwei prominenten Exilösterreichern – dem Soziologen Paul F. Lazarsfeld und dem Ökonomen Oskar Morgenstern – mit Hilfe der Ford-Stiftung, des Österreichischen Bundesministeriums für Unterricht und der Stadt Wien gegründet und ist somit die erste nachuniversitäre Lehr- und Forschungsstätte für die Sozial- und Wirtschaftswissenschaften in Österreich. Die **Reihe Ökonomie** bietet Einblick in die Forschungsarbeit der Abteilung für Ökonomie und Finanzwirtschaft und verfolgt das Ziel, abteilungsinterne Diskussionsbeiträge einer breiteren fachinternen Öffentlichkeit zugänglich zu machen. Die inhaltliche Verantwortung für die veröffentlichten Beiträge liegt bei den Autoren und Autorinnen.

Abstract

The Balassa-Samuelson (BS) effect is usually considered as the prime explanation of the continuous real exchange rate appreciation of the central and east European (CEE) transition countries against their western European counterparts. This paper tries to explain relative price differentials observed over the past decade between four CEE economies - Slovakia, the Czech Republic, Hungary and Poland - and Euro area in terms of productivity growth differentials.

Using panel estimation techniques, we find strong empirical evidence in favour of the BS hypothesis. Furthermore, relaxing some of the assumptions (i.e. PPP holds for tradable goods) results in little support of BS hypothesis. Our estimates of the BS term suggest that the Balassa-Samuelson effect in these 4 CEE countries does not have to be as sizeable as other studies propose.

Keywords

Balassa-Samuelson effect, Purchasing Power Parity (PPP), real exchange rate appreciation, transition economies

JEL Classifications

E31, F31, C23

Comments

I would like to thank Walter Fisher for supervision, encouragement and useful discussion. I am grateful to Andrea Weber, Martin Wagner and Jaroslava Hlouskova for valuable comments. Moreover, I thank Jan Kuchta, Miroslav Kotov, Andrej Probst and Katarina Krivanska for help with data issues.

Contents

1	Introduction	1
2	PPP and Balassa-Samuelson effect	2
3	Analytical framework	3
3.1	The standard Balassa-Samuelson model	3
3.2	The first modification of Balassa-Samuelson model	6
3.3	The second modification of Balassa-Samuelson model	6
4	Empirical framework	7
4.1	The data and sectoral disaggregation	7
4.2	Various measures of productivity	8
4.3	Preliminary look at the data	9
4.4	Estimates of Balassa-Samuelson term	16
5	Conclusion	29
	Appendix I. The first-order conditions	31
	Appendix II. Economies and periods covered	33
	References	34

1 Introduction

In the near future, some countries from Central and Eastern Europe will join the European Union and the enlargement process is likely to continue. Most transition economies have experienced prolonged and often massive real exchange rate appreciation with the greatest rate of appreciation taking place in the first few years of transition. A study by Halpern and Wyplosz (1997, 1998) on a set of selected transition economies demonstrated that real appreciation might be labelled *a stylized fact of transition*. This finding has been later confirmed in various other studies (e.g. Rosati 1997, Desai 1998).

Recently, there is a fast growing empirical literature on transition economies concentrating both on relative price and real exchange rate developments related to the Balassa-Samuelson effect. According to the estimation techniques, recent papers attributable to real appreciation of EU accession countries' currencies can be categorized into two main streams.

The first strand of literature considers "*standard*" estimation methods (e.g. OLS, GLS, pooled estimation) and the estimates of productivity driven real appreciation are approximately 3 *per cent* per annum in a number of transition economies (Simon and Kovacs 1998, Rother 2000, Halpern and Wyplosz 2001). All of the mentioned papers conclude that the Balassa-Samuelson effect plays an important role in explaining the real exchange rate appreciation of EU accession candidates. By contrast, authors implementing "*sophisticated*" cointegration techniques attain lower magnitude of estimates ranging from -0.2 to 1.5 % a year (Egert 2001, Jazbec 2001). These techniques (unit root tests, VAR-based cointegration proposed by Johansen) were designed to look for a long-run relationship and due to short time span data availability among EU accession countries are not recommended.

This paper addresses the question which factors might cause the stylized fact that the exchange rates of transition economies appreciate in real terms. This empirical study contributes to the debate on EU accession countries by investigating the Balassa-Samuelson effect for 4 CEE transition countries using detailed national accounts data for productivity and relative price measure. The contribution of this paper is twofold:

- to estimate the Balassa-Samuelson effect for 4 CEE transition countries (using

more complete and, thus, a "better" measure of productivity, i.e., total factor productivity TFP instead of frequently used labour productivity) and to see to what extent a relative price differential between accession countries and EU area can be explained by a productivity differential;

- to relax some assumptions of the standard Balassa-Samuelson model (e.g. PPP holds for tradable goods, wage equalization). None of the studies thus far attributable to CEE transition economies tried to evaluate the Balassa-Samuelson effect under these modified assumptions. This paper will attempt to fill this gap.

The remainder of this paper is structured as follows: *Section 2* briefly discusses the theoretical framework. *Section 3* describes assumptions for the standard Balassa-Samuelson model and analytically derives the relationship between relative price differential and productivity differential under different assumptions. *Section 4* presents the empirical framework, i.e., data and econometric technique employed. Finally, *Section 5* reviews the main findings.

2 PPP and Balassa-Samuelson effect

There are two alternative theories to explain real exchange rate movements. The first is *Purchasing Power Parity*¹ (PPP) according to which the real exchange rate must be stationary. This implies there cannot exist persistent deviations from the real exchange equilibrium level, but only temporary ones. In this case PPP serves as a good first approximation to long-run behaviour.

The second, the *Balassa-Samuelson* hypothesis, which seeks to explain the persistence of real exchange rate changes, typically focuses on the tradeability of goods. According to Balassa (1964) and Samuelson² (1964), rapid economic growth is accompanied by real exchange appreciation because of differential productivity growth between tradable and non-tradable sectors. Since the differences in productivity increases are expected to be larger in high growth countries, the Balassa-Samuelson prediction should be more visible among fast growing countries.

¹The theory of Purchasing Power Parity predicts that real exchange rates should be equal to 1, or at least have tendency to return quickly to 1 when that long-run ratio is disturbed for some reason. Sometimes this version of PPP is called *absolute* PPP. *Relative* PPP is the weaker statement that changes in national price levels always are equal or, at least, tend to get equalized over sufficiently long periods (Obstfeld and Rogoff, 1996).

²Actually, the main motivation behind their model was to explain the persistent deviation from PPP. This framework was initially introduced by Harrod (1993) and some literature still refers to the *Harrod-Balassa-Samuelson effect*.

The productivity approach seems to be a natural candidate for analyzing real exchange rates in transition economies. The *Balassa-Samuelson effect* explains a tendency for countries with higher productivity in tradables, compared with non-tradables, to have a higher aggregate price level (Obstfeld and Rogoff, 1996).

Historically, productivity growth in the traded goods sector has been faster than in the non-traded goods sector. According to the theory of PPP, the prices of tradables tend to get equalized across countries, while the prices of nontradables do not. Increased productivity in the traded good sector will bid up wages in that sector and, with labour mobility, wages in the entire economy will rise. Producers of non-traded goods will be able to pay the higher wages only if there is a rise in relative price of non-traded goods. This will in general lead to an increase in the overall price level in economy.

3 Analytical framework

This section provides a benchmark model which will be a subject to several modifications. The first alternative specification is related to the labour markets and the second one to the traded goods sectors.

3.1 THE STANDARD BALASSA-SAMUELSON MODEL

To illustrate the Balassa-Samuelson effect, let us consider a traditional two-country model with two goods: *traded* (T) and *non-traded* (N). The "standard" Balassa-Samuelson model has three assumptions: first, capital is mobile, both internationally and between sectors; second, labour is free to migrate between sectors but not between countries; and third, PPP holds only for tradable goods. The second assumption implies that wages tend to be equalized across sectors or, at least, their relative position remains constant.

To formalize this model, we specify that the aggregate price level is first decomposed into its traded and non-traded components, both at home and in the foreign country:

$$p_t = \alpha p_t^T + (1 - \alpha) p_t^N \quad (1)$$

$$p_t^* = \alpha^* p_t^{T*} + (1 - \alpha^*) p_t^{N*} \quad (2)$$

where p_t^T denotes the price of traded goods, p_t^N denotes the price of non-traded

goods, the parameter α denotes the share of traded goods in consumption basket, and the asterix " * " denotes foreign country.

The real exchange rate q_t is defined as the relative price of goods produced abroad (measured in domestic currency) to domestically produced goods:

$$q_t = (e_t + p_t^*) - p_t \quad (3)$$

where e_t is the nominal exchange rate (expressed in units of the domestic currency per unit of the foreign currency). Then first differences of real exchange rate can be obtained:

$$\Delta q_t = (\Delta e_t + \Delta p_t^{T*} - \Delta p_t^T) + [(1 - \alpha^*)(\Delta p_t^{N*} - \Delta p_t^{T*}) - (1 - \alpha)(\Delta p_t^N - \Delta p_t^T)]. \quad (4)$$

If the PPP holds for tradables, i.e. $\Delta p_t^T = \Delta e_t + \Delta p_t^{T*}$, then the first term on the right-hand-side of (4) disappears.

Assuming a small open economy framework, the output in each sector ($Y^i, i = T, N$) is determined by a Cobb-Douglas production technology:

$$Y_t^T = A_t^T (L_t^T)^\gamma (K_t^T)^{1-\gamma} \quad (5)$$

$$Y_t^N = A_t^N (L_t^N)^\delta (K_t^N)^{1-\delta} \quad (6)$$

where K, L, A denote capital, labour and productivity. Each sector differs in the labour intensities γ and δ , which reflects the shares of labour in the traded and non-traded sectors, respectively.

Profit maximization implies that under perfect competition the interest rate R and the nominal wage in each sector W^T, W^N fulfill following conditions³:

$$R_t = (1 - \gamma)A_t^T \left(\frac{K_t^T}{L_t^T}\right)^{-\gamma} = P_{REL}(1 - \delta)A_t^N \left(\frac{K_t^N}{L_t^N}\right)^{-\delta} \quad (7)$$

$$W_t^T = \gamma A_t^T \left(\frac{K_t^T}{L_t^T}\right)^{1-\gamma} \quad (8)$$

$$W_t^N = P_{REL} \delta A_t^N \left(\frac{K_t^N}{L_t^N}\right)^{1-\delta} \quad (9)$$

where $P_{REL} = P_t^N / P_t^T$ is the relative price of non-tradables. It is convenient to express these equilibrium conditions in logarithmic terms⁴:

$$r_t = \log(1 - \gamma) + a_t^T - \gamma(k_t^T - l_t^T) = p_{REL} + \log(1 - \delta) + a_t^N - \delta(k_t^N - l_t^N) \quad (10)$$

³See *Appendix I*.

⁴Throughout the paper, lower case letters refers to variables in logs.

$$w_t^T = \log \gamma + a_t^T + (1 - \gamma)(k_t^T - l_t^T) \quad (11)$$

$$w_t^N = p_{REL} + \log \delta + a_t^N + (1 - \delta)(k_t^N - l_t^N) \quad (12)$$

where a^i , $i = T, N$ represents total factor productivity in the sector concerned.

We follow the standard assumption that capital markets are perfectly competitive and integrated, so that the interest rate is given by the international financial market. As far as the labour market is concerned, we consider two alternatives. In the "*standard*" specification, we assume that wages tend to be equalized across sectors, i.e. $w_t^T = w_t^N$. By solving equations (10)-(12), we obtain the following ("*domestic*") version of the Balassa-Samuelson hypothesis⁵:

$$p_{REL} = p_t^N - p_t^T = c + \frac{\delta}{\gamma} a_t^T - a_t^N \quad (13)$$

where c is a constant term which includes the real interest rate and factor intensities. The equation (13) captures the *Baumol-Bowen effect*, which is closely related to but distinct from the Balassa-Samuelson effect. Baumol and Bowen (1966) argued that within a country there is a rising trend in the ratio of non-tradable to tradable prices, which is caused by higher productivity in the traded goods sector than in non-traded goods sector⁶ (Obstfeld and Rogoff, 1996).

By substituting (13) into (4) and using PPP for tradables one obtains the "*standard*" specification of the Balassa-Samuelson hypothesis:

$$\Delta p_t - \Delta p_t^* = \Delta e_t + (1 - \alpha) \left[\frac{\delta}{\gamma} \Delta a_t^T - \Delta a_t^N \right] - (1 - \alpha^*) \left[\frac{\delta^*}{\gamma^*} \Delta a_t^{T*} - \Delta a_t^{N*} \right] \quad (14)$$

The change in the relative price differential in an accession country and the Euro area can thus be expressed as a sum of the nominal exchange rate of the accession country's currency vis-a-vis the euro, Δe_t , and the productivity growth differentials between the traded and non-traded goods sectors in the accession country ($\Delta a_t^T - \Delta a_t^N$) and the Euro area ($\Delta a_t^{T*} - \Delta a_t^{N*}$) weighted by a share of non-tradables in consumption basket $(1 - \alpha)$.

By imposing the simplifying assumption that both countries' sectoral outputs are proportional to same production function, and rearranging terms, we can show

⁵See *Appendix I*.

⁶It is plausible to assume that $\delta/\gamma \geq 1$, i.e. non-traded goods are more labour intensive than traded. Then higher productivity in traded good sector than in non-traded sector, $a_t^T > a_t^N$, will cause appreciation of the relative price of non-tradables, $p_t^N > p_t^T$.

that home country (accession country) will experience a *real appreciation* (a rise in its relative price level) if productivity growth differential in tradables exceeds productivity growth differential in non-tradables.

3.2 THE FIRST MODIFICATION OF BALASSA-SAMUELSON MODEL

An alternative specification captures two facts about labour markets. First, labour is not homogenous due to differences in skills or human capital. Second, we also know that labour is not fully employed, due to frictions or rigidities. In order to take in account this possibility, we obtain an "*extended*" version of equation (13):

$$p_{REL} = p_t^N - p_t^T = c + \frac{\tilde{\delta}}{\tilde{\gamma}} a_t^T - a_t^N - \tilde{\delta}(w_t^T - w_t^N) \quad (15)$$

where the additional term on the right-hand-side is the wage differential⁷, and $\tilde{\delta} \equiv 1 - \delta$, resp. $\tilde{\gamma} \equiv 1 - \gamma$ are the capital intensities.

By substituting (15) into (4) and using PPP for tradables we obtain the "*extended*" specification of the Balassa-Samuelson hypothesis:

$$\begin{aligned} \Delta p_t - \Delta p_t^* &= \Delta e_t + (1 - \alpha) \left[\frac{\tilde{\delta}}{\tilde{\gamma}} \Delta a_t^T - \Delta a_t^N \right] - (1 - \alpha^*) \left[\frac{\tilde{\delta}^*}{\tilde{\gamma}^*} \Delta a_t^{T*} - \Delta a_t^{N*} \right] \\ &\quad + \tilde{\delta}^*(1 - \alpha^*)(\Delta w_t^{T*} - \Delta w_t^{N*}) - \tilde{\delta}(1 - \alpha)(\Delta w_t^T - \Delta w_t^N) \end{aligned} \quad (16)$$

where the change in the relative price differential in an accession country and the Euro area depends on sectoral productivity growth - and wage growth - differentials in the two countries concerned.

3.3 THE SECOND MODIFICATION OF BALASSA-SAMUELSON MODEL

None of the studies thus far tried to estimate equation (4) without assuming that PPP holds for tradables. To extend the research in this area, we will relax the assumption of PPP for tradables in an empirical investigation. In reality, PPP might fail to hold for several reasons, e.g., different consumption baskets across countries, trade barriers, imperfect competition. According to Engel (1999), the deviation in the real exchange rate (failure of PPP) can be decomposed into two types: first, deviations in traded goods prices *across* countries; second, deviations in relative price of traded to non-traded goods prices *within* countries. His results

⁷See *Appendix I*.

were that the deviations in real exchange rate are due to the first type. So it seems to be reasonable to focus on a "full" version of equation (4) that does not assume that the first term on the right-hand-side disappears due to PPP.

In this more general case, we obtain a "full" specification of the Balassa-Samuelson hypothesis:

$$\Delta p_t - \Delta p_t^* = \Delta p_t^T - \Delta p_t^{T*} + (1 - \alpha) \left[\frac{\delta}{\gamma} \Delta a_t^T - \Delta a_t^N \right] - (1 - \alpha^*) \left[\frac{\delta^*}{\gamma^*} \Delta a_t^{T*} - \Delta a_t^{N*} \right] \quad (17)$$

where the change in the relative price differential in an accession country and the Euro area depends on sectoral productivity growth - and tradable price - differentials in the two countries concerned.

4 Empirical framework

This section presents a brief discussion of the data construction, implemented methods and empirical results.

4.1 THE DATA AND SECTORAL DISAGGREGATION

Many empirical studies related to the Balassa-Samuelson effect suffer to varying degrees from data measurement problems. First, many authors use annual data and try to resolve the problem of a short time span by cross-section analysis. Such pooled time series contain very heterogeneous economies, from advanced EU accession candidates to less developed countries. To reduce disparity between countries, we will empirically investigate the *Vysegrad Pact* countries: Slovakia, the Czech Republic, Hungary and Poland, which seem to be economically and historically similar.

This paper tests empirically the Balassa-Samuelson hypothesis using quarterly data⁸ covering period from 1995:1 to 2002:4. We eliminated the early years of transition (late 80's and early 90's), during which price and productivity developments were much more driven by initial reforms rather than by the Balassa-Samuelson effect itself.

Second, the sectoral data are highly aggregated. One crucial issue is how to define the traded and non-traded sector. The traded good sector usually includes industry: manufacturing, mining, construction, and some authors add gas, electricity and

⁸For more details on the data, particularly their definitions and sources see *Appendix II*.

water supply, industries whose output is to a small extent traded. The non-traded sector covers all services, some authors involve also construction, and gas, electricity and water supply. No consensus has been reached in the literature on this issue (see Table 1).

Categorization in this paper partially corresponds to the one used by Simon and Kovacs (1998), we classify manufacturing as a tradable sector (we excluded mining, and water, electricity and water supply), and services and construction as non-tradables. We excluded agriculture from tradables because this sector is distorted by the large number of the seasonal and part-time workers. The reason for the elimination of the other sectors was the limited data availability on productivity.

Table 1. An overview of sector classification

Author	Country sample	Traded sector	Non-traded sector
Simon&Kovacs (1998)	Hungary 91-96	Manufacturing (excl. agriculture, mining and energy)	Services (excl. public administration)
Rother (2000)	Slovenia 93-98	Manufacturing	Residuals (excl. agriculture)
Halpern, Wyplosz (2001)	8 accession candidates + Russia 91-98	Industry	Services
Egert (2001)	5 accession candidates 91-00	Industry	Not considered (productivity set at zero)
Jazbec (2001)	19 transition economies 90-98	Manufacturing, mining, energy, construction	Residuals
Fisher (2001)	10 accession candidates 93-99	Industry	Services
Mihaljek (2002)	6 accession candidates 95-02	Manufacturing, mining, transportation, communications, tourism	Energy, construction, services, education, health

4.2 VARIOUS MEASURES OF PRODUCTIVITY

There are two main measures of productivity. First, *labour productivity* is labelled as "output per worker" or "output per hour", and thus measures the average number of units of goods or services produced per hour worked or per worker. Labour productivity is frequently used for analysis attributable to the Balassa-Samuelson effect, because it is relatively simple to estimate⁹.

⁹All previously mentioned authors are using "production divided by employment" as measure

Labour productivity is a partial factor productivity measure, i.e. it is the ratio of output per unit of labour input only, holding other economic factors of production such as land, capital, and materials constant. On the other hand, *total factor productivity* (TFP) is a more complete measure of productivity that relates output not only to labour input, but to a combined measure of all inputs, including capital and material inputs.

TFP growth is closely related to the theoretical framework of Solow residuals, which represents the unexplained part of output growth. In principle, they are the same¹⁰, but OECD International Sectoral Database provides TFP with standardized labour weights of 70 *per cent* for all sectors and countries, with the exception of the following sectors: "electricity, gas and water", "mining", "finance, insurance, real estate and business services" and "real estate", where a labour weight of 33 % is used.

In this paper, we estimate the Balassa-Samuelson term for 4 EU accession candidates using more complete and, thus, "better" measure of productivity; i.e., TFP instead of frequently used labour productivity. In this respect, this study tries to give more precise results.

4.3 PRELIMINARY LOOK AT THE DATA

Real exchange rates certainly belong to those macroeconomic variables whose pattern of movement seems to be a diagnostic for transition economies: as a rule, they appreciate in real terms.

for productivity, exception among them is MacDonald and Ricci (2001), they employed TFP obtained from OECD International Sectoral Database.

¹⁰In order to get a closer look at the derivation of TFP, we provide formula used by OECD:

$$TFP = [\frac{VA}{ET^{(w)} * GCS^{(1-w)}}] / TFP_0$$

where TFP denotes total factor productivity, GCS gross capital stock, VA gross value added, w standardized labour share weights and TFP_0 total factor productivity, 1995 value. In the context of our model, the procedure for Solow residuals would require the estimation of production function for traded sector:

$$\log Y_t^T = \gamma \log L_t^T + (1 - \gamma) \log K_t^T + u_t^1$$

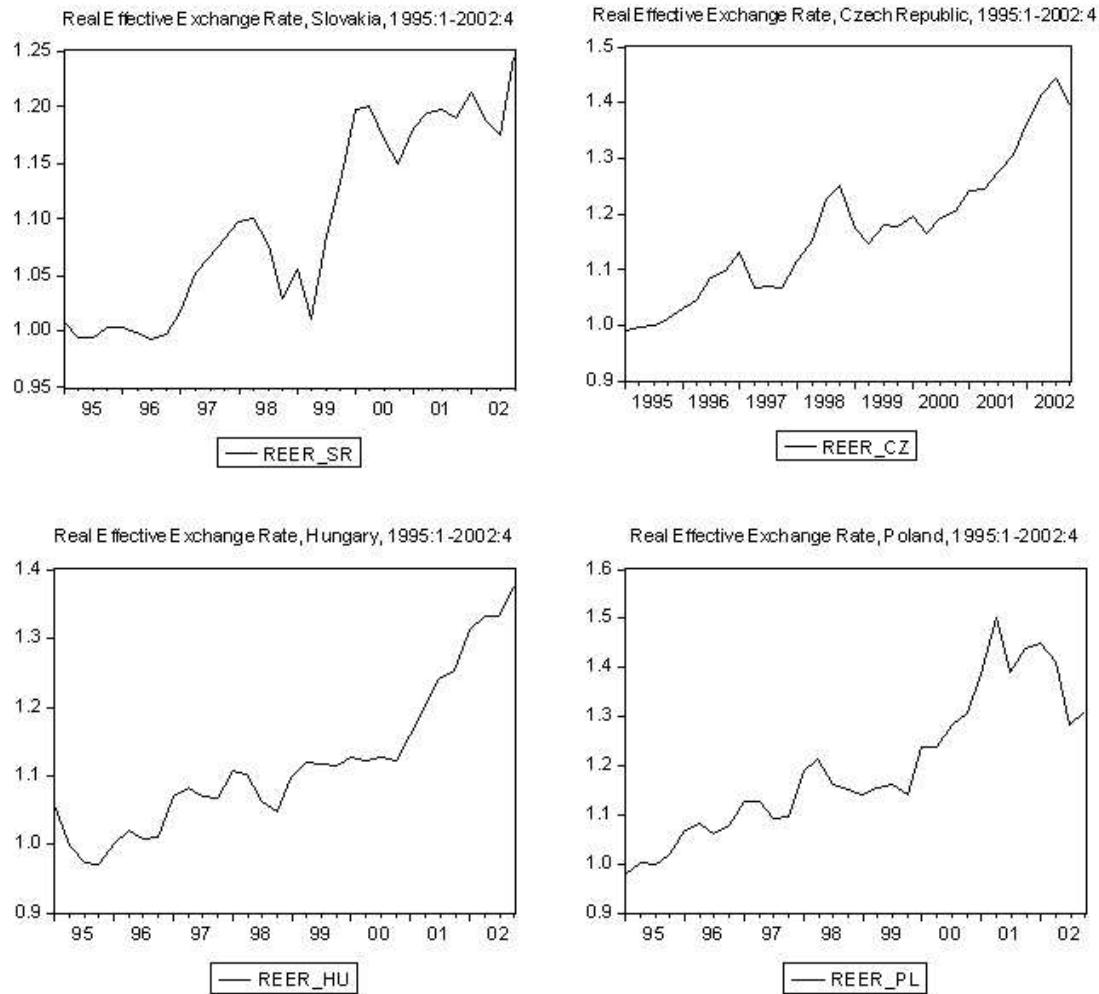
and similarly, for non-traded:

$$\log Y_t^N = \delta \log L_t^N + (1 - \delta) \log K_t^N + u_t^2$$

where u_t^1 , u_t^2 are Solow residuals.

In order to demonstrate a real appreciation,¹¹ we focus our attention on evolution real exchange rate. Figure 1 shows the real effective exchange rate of 4 CEE transition countries that are currently negotiating accession to EMU (Slovakia, the Czech Republic, Hungary and Poland will become EU members in 2004). Across all 4 countries, we can observe a positive trend in their real effective exchange rate. The reason why the real effective exchange rate (REER) has been chosen instead of the frequently used bilateral real exchange rate (usually against USD or EUR) is because it provides a richer measure of competitiveness.

Figure 1. Real effective exchange rates

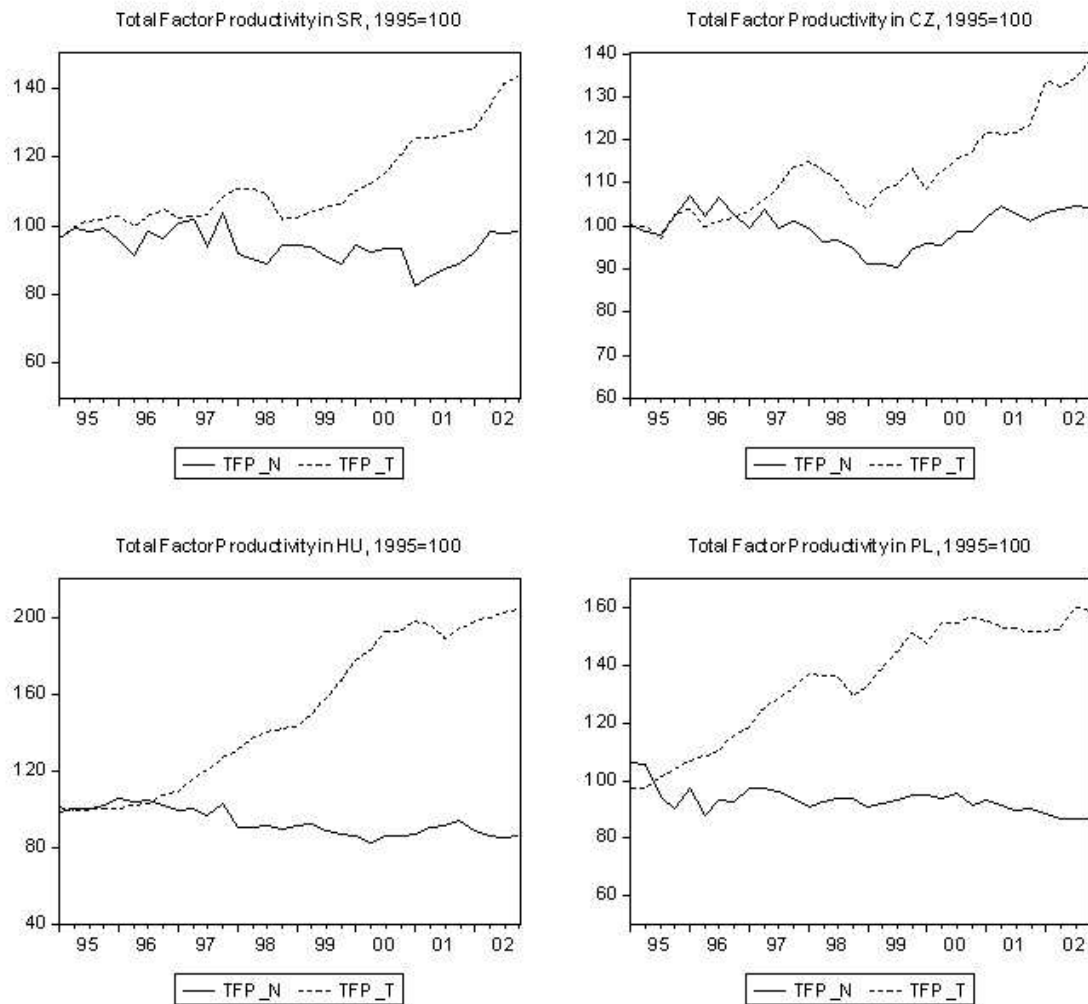


¹¹For two countries *home* and *foreign* with price level P and P^* (measured in same numeraire), we say that home country experiences a *real appreciation*, and foreign *real depreciation*, when P/P^* rises. If the real exchange rates are defined as P/eP^* , where e is nominal exchange rate in units of domestic currency, then an increase in real exchange rate denotes real appreciation.

In order to get an overview of the Balassa-Samuelson hypothesis, the sectoral data on productivity and prices in the following 4 accession counties are considered. The series are smoothed by the seasonal adjustment X-11¹².

As Figure 2 indicates, the productivity in the traded sector has been growing faster than in non-traded sector over the whole sample period, except the period 1995-96 in Czech Republic and Hungary, and year 1995 in Poland. After the initial recession, these countries have experienced rapid productivity growth, particularly in their industrial sectors. Decades of central planning have resulted in emphasis on material production, while services were largely neglected (the productivity trend in non-traded sector is almost zero, in some countries negative).

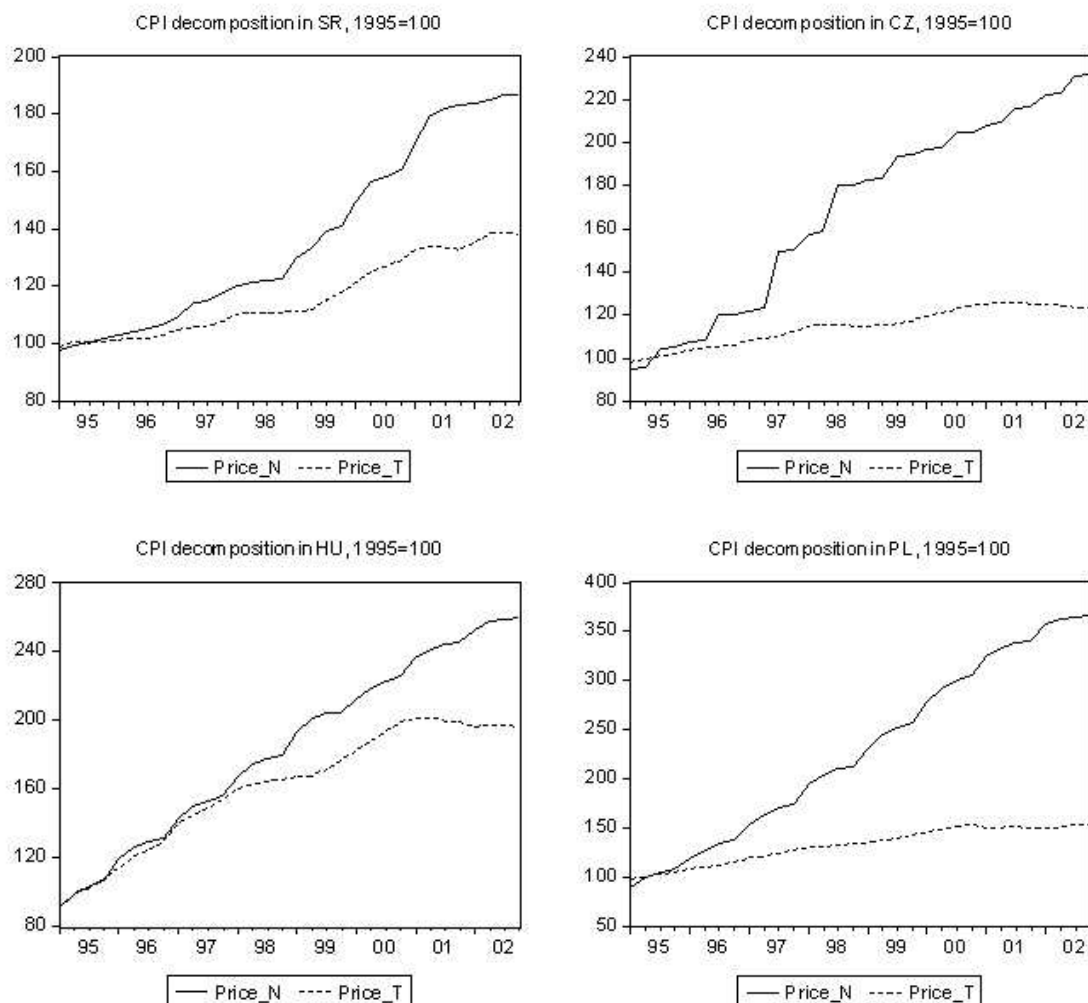
Figure 2. Total factor productivity in traded and non-traded sector



¹²EViews provides the seasonal adjustment program *Census* X-11 which is the standard method used by the U.S. Bureau of Census to seasonally adjust publicly released data.

According to the Balassa-Samuelson hypothesis, the faster productivity growth in the traded sector should result in faster growth of the non-traded prices. Figure 3 demonstrates that this has been the case. Actually, this implication relates only to one (the "home") country, and should be correctly referred to the "domestic" Balassa-Samuelson hypothesis.

Figure 3. Prices in traded and non-traded sector



The core of the productivity hypothesis is presented in Figure 4. The relative prices (non-traded relative to traded) have tended to rise as the relative productivity (traded relative to non-traded) has increased. This is in fact the Baumol-Bowen effect, which is closely related to but distinct from the Balassa-Samuelson effect. The Baumol-Bowen effect takes place in the "home" country, while the Balassa-Samuelson effect compares two countries: domestic *versus* foreign.

Figure 4. The Baumol-Bowen effect

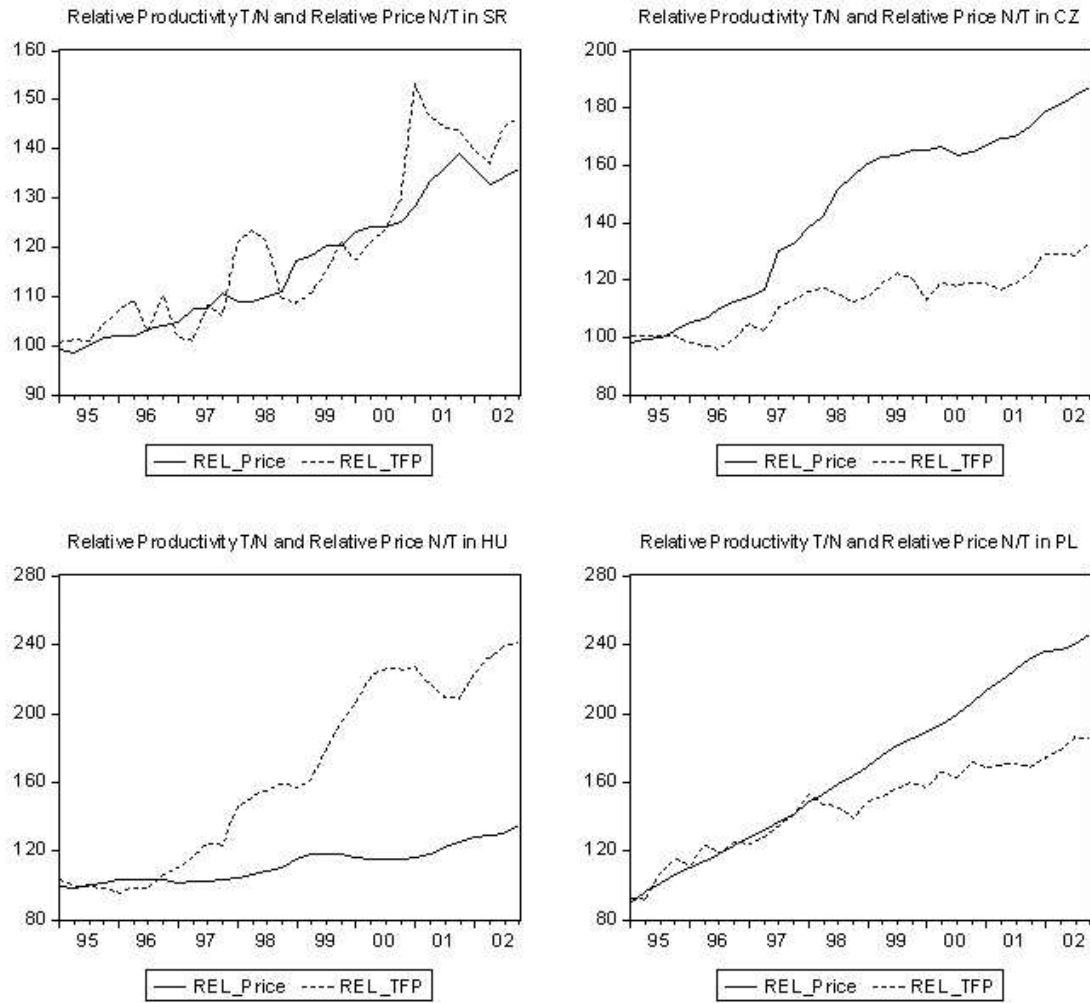
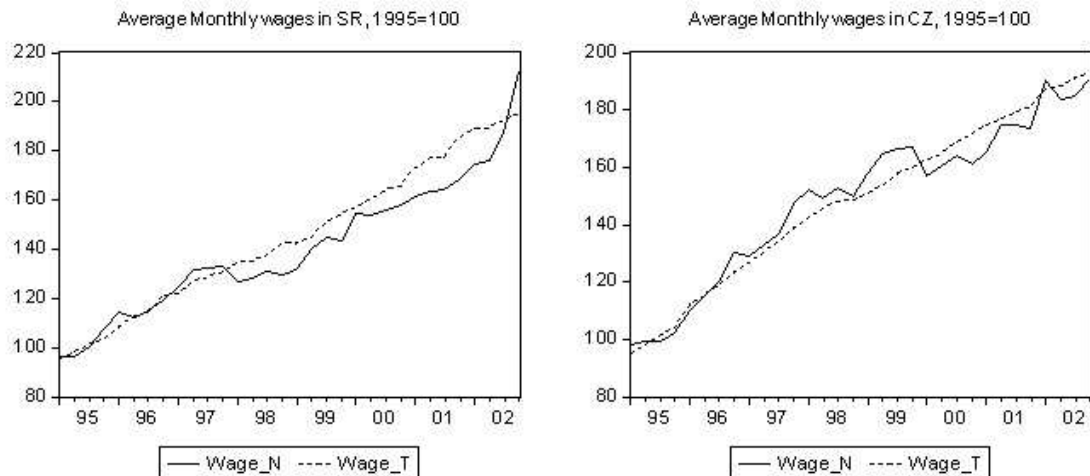


Figure 5 describes the evolution of nominal wages in the traded and non-traded sector in these 4 CEE countries.

Figure 5. Nominal wages in traded and non-traded sector



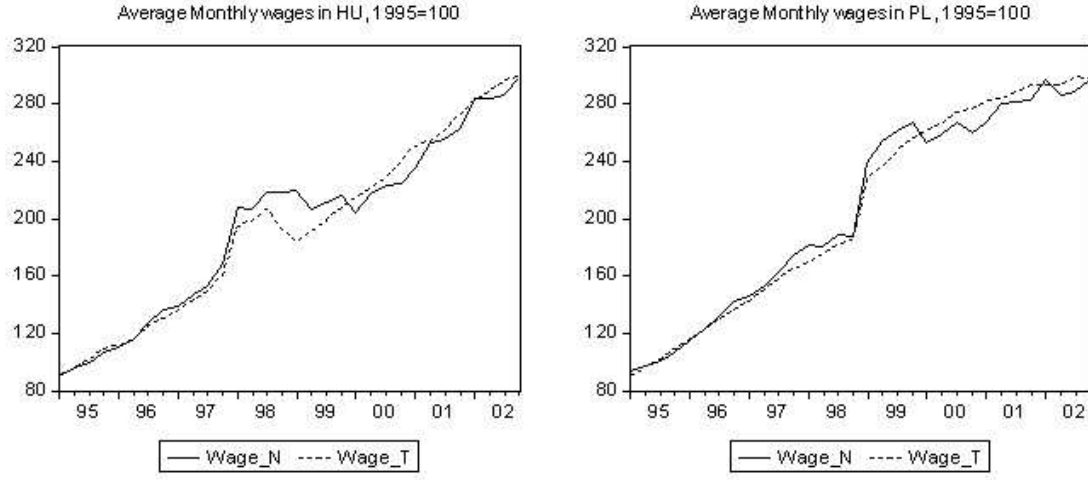
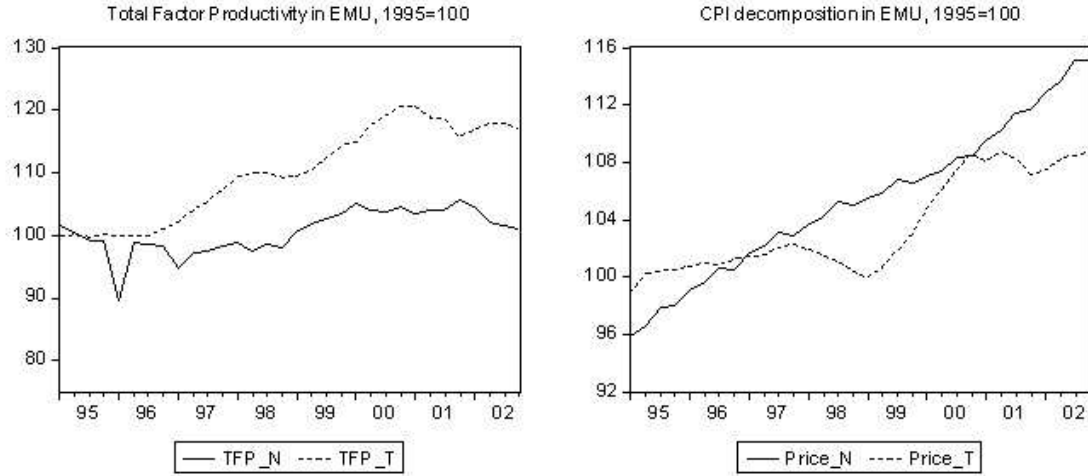


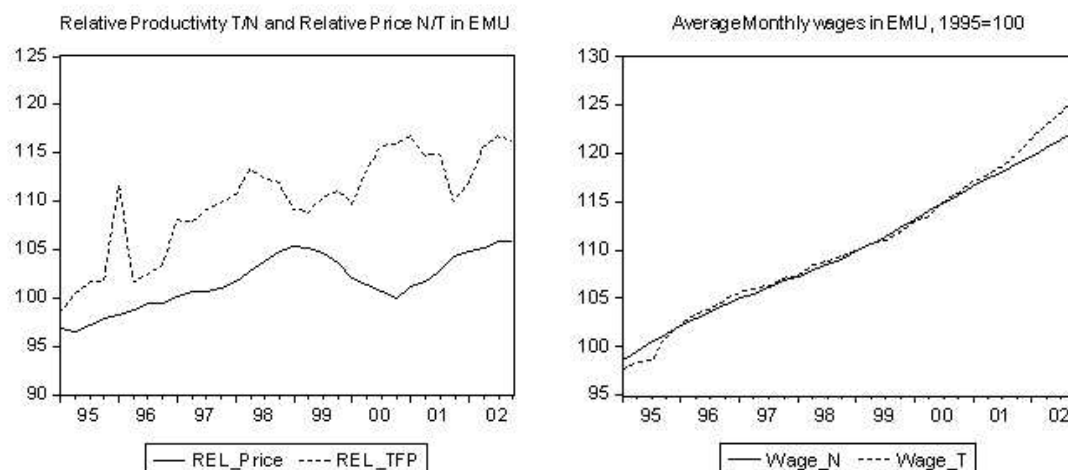
Figure 6 provides the same analysis for the Euro area. The first panel indicates that the productivity growth in the traded good sector has been higher than in the non-traded good sector. Higher productivity in the traded sector translates into higher prices in the non-traded sector. The second panel shows that the “domestic” Balassa-Samuelson hypothesis holds from the middle of 1996. As the third panel demonstrates, except the period 1999-01, the Baumol-Bowen effect seems to hold, i.e., the relative price have tended to rise as the relative productivity has increased. In the fourth panel, the wages in both sectors move together.¹³

Figure 6. Euro area



¹³Due to the wage equalization in the Euro area, the wage growth differential in the foreign country ($\Delta w_t^{T*} - \Delta w_t^{N*}$) will disappear from equation (16), i.e. we will estimate the following equation:

$$\Delta p_t - \Delta p_t^* = \Delta e_t + (1 - \alpha) \left[\frac{\tilde{\delta}}{\gamma} \Delta a_t^T - \Delta a_t^N \right] - (1 - \alpha^*) \left[\frac{\tilde{\delta}^*}{\gamma^*} \Delta a_t^{T*} - \Delta a_t^{N*} \right] - \tilde{\delta} (1 - \alpha) (\Delta w_t^T - \Delta w_t^N).$$



In Table 2, the same information is summarized for the accession countries in the terms of growth, i.e., the productivity growth and the inflation rate. Observe that the average productivity growth in the traded sector ranges from 4.5 % in the Czech Republic to 10.8 % in Hungary. On the other hand, the average productivity growth in the non-traded sector moves around 0 % or is even negative, the case of Hungary and Poland. The average inflation rate lies in interval 5.8 % and 12.9 %. Compared to the Euro area, the average productivity growth in the traded sector is 2.4 %, in the non-traded sector 0.4%, and inflation rate is 2.1 %.

Table 2. Average productivity growth and inflation rate

Country	Period	Productivity growth in traded sector	Productivity growth in non-traded sector	Inflation rate
Slovakia	1995-2002	4,76%	0,01%	7,40%
Czech Republic	1995-2002	4,49%	0,69%	5,79%
Hungary	1995-2002	10,78%	-1,80%	12,92%
Poland	1995-2002	6,77%	-1,71%	10,18%
Euro Area	1995-2002	2,36%	0,41%	2,09%

The Balassa-Samuelson model presented in Section 3 suggests that there is a specific relationship between the relative price differential, the productivity differential and, potentially, the wage differential.

At first, we will provide individual country estimates of the Balassa-Samuelson term obtained by ordinary least squares. The use of quarterly data and the short sample period (1995:1-2002:4) makes the application of time series techniques extremely difficult, and it must be stressed out that the results should be treated and interpreted with caution. To resolve this power problem, in second part of our empirical analysis, we employ panel regressions.

For each country, we estimate three models:

- "*standard*" specification of BS hypothesis (equation 14);
- "*full*" specification of BS hypothesis (equation 17) without assuming that PPP holds for tradables;
- "*extended*" specification of BS hypothesis (equation 16) without assuming that wages tend to get equalized across sectors.

An additional explanatory variable, the real interest rate differential, is added to each regression equation. Recall that the real interest rate was captured in constant term c of equation (8).

Some additional simplifying assumptions are worth of noting. None of the empirical papers studying the Balassa-Samuelson effect (including this one) tries to regress these equations with different relative labour intensities in the non-traded and traded sectors δ/γ . As argued by Mihaljek (2002), the use of these intensities can significantly affect the magnitude of estimated BS term. Due to the lack of the sectoral employment data, we set the ratio of labour intensities to one in our empirical work.

According to the theoretical model presented earlier in this paper, an increase (decrease) in the productivity differential should result in increase (decrease) in the relative price differential. In other words, the estimates of the Balassa-Samuelson term should have a positive sign.

Individual country estimates of BS term:

First, we estimate the following equation, which represents the "standard" specification of BS hypothesis:

$$(\Delta p^{CEE} - \Delta p^{EA})_t = \beta_1 \Delta e_t^{CEE} + \beta_2 [(1 - \alpha^{CEE})(\Delta a_T^{CEE} - \Delta a_N^{CEE})_t - (1 - \alpha^{EA})(\Delta a_T^{EA} - \Delta a_N^{EA})_t] + \varepsilon_t \quad (18)$$

where Δp is the gross inflation rate, Δe is the rate of change of the nominal exchange rate, Δa_T and Δa_N are the growth rates of productivities (gross), ε_t are residuals and β 's are the estimated coefficients, the superscript CEE denotes the central European country (SR, CZ, HU, PL) and EA the Euro area.

Throughout this paper, the coefficient β_2 refers to the *Ballasa-Samuelson effect*¹⁴, which measures the impact of the productivity growth on the relative prices. The results are reported in Tables 3 - 6 at the end of this section. The first two columns provide the coefficients of the benchmark model (case A indicates that the real interest rate has been added).

Then, the following null hypothesis is tested:

$$H_0 : \beta_2 = 0 \quad \text{against} \quad H_0 : \beta_2 > 0$$

where the alternative hypothesis represents the Balassa-Samuelson hypothesis (productivity differential has a positive impact on relative price differential).

The first columns in Tables 3 - 6 show that a percentage point increase in the productivity differential in Slovakia is associated with an increase of about 2.5 % in the relative prices when compared to the Euro area. In the Czech Republic, if the productivity differential rises by 1 %, the relative price of non-traded to traded goods increases by 1.9 %. According to these estimates, the productivity growth differential results in 2.8 percentage point higher relative prices in Hungary, and 3.4 percentage point higher relative prices in Poland. Adding the real interest rate is accompanied by lower magnitude of the BS term (except Slovakia), and

¹⁴In order not to confuse the reader, we provide a brief revision of terminology used. The *Ballasa-Samuelson effect* explains a tendency for countries with higher productivity in tradables, compared with non-tradables, to have a higher aggregate price level (Obstfeld and Rogoff, 1996). In this paper the Ballasa-Samuelson effect is captured by coefficient β_2 . The *Ballasa-Samuelson term* is $[(1 - \alpha^{CEE})(\Delta a_T^{CEE} - \Delta a_N^{CEE})_t - (1 - \alpha^{EA})(\Delta a_T^{EA} - \Delta a_N^{EA})_t]$. And the *Ballasa-Samuelson hypothesis* tests whether the productivity growth differential has a positive influence on the relative price differential. In the empirical work, we test the null hypothesis $H_0 : \beta_2 = 0$.

enters insignificantly¹⁵. For all countries, we rejected the null hypothesis, i.e., the productivity growth differential has a positive influence on relative price differential. According to the magnitude of the estimates, there is a strong evidence for the Balassa-Samulson effect.

Second, we explore the stationarity of the real exchange rate using augmented Dickey-Fuller test for unit root. The real exchange rates appear difference stationary I(1), i.e., PPP does not hold¹⁶. And thus, it seems to be reasonable investigate the Balassa-Samuelson effect under this general assumption (see equation 17).

We estimate the following equation, which represents the "*full*" specification of the BS hypothesis without assuming that PPP holds for tradables¹⁷ :

$$(\Delta p^{CEE} - \Delta p^{EA})_t = \beta_1(\Delta p_T^{CEE} - \Delta p_T^{EA})_t + \\ + \beta_2[(1 - \alpha^{CEE})(\Delta a_T^{CEE} - \Delta a_N^{CEE})_t - (1 - \alpha^{EA})(\Delta a_T^{EA} - \Delta a_N^{EA})_t] + \varepsilon_t \quad (19)$$

where all variables are defined as in equation (18) and Δp_T denotes the gross rate of PPI inflation¹⁸.

The second two columns in Tables 3 - 6 provide the coefficients of the "*full*" Balassa-Samuelson model. Not assuming that PPP holds for tradables results in little support of BS hypothesis, the coefficients of BS term are around zero or even negative. In all cases, except Hungary and Poland, we do not reject the null hypothesis, i.e., the productivity growth differential has no impact on the relative price differential. In Hungary and likewise in Poland, a percentage point higher growth of the productivity differential will result in 0.4 percentage point higher relative prices compared to the Euro area. The estimated coefficients on tradable price differential ($\hat{\beta}_1$ in equation 19) are statistically significant in all regressions, and range in value from 0.9 (Hungary) to 1.7 (Slovakia and Czech Republic).

Finally, the empirical evidence that wages do not tend to equalize across sectors leads us to derive a second modification of the Balassa-Samuelson model. Following Section 3.2, we estimate the regression equation, which represents the "*extended*"

¹⁵MacDonald and Ricci (2001) found the same results investigating 10 European countries.

¹⁶According to PPP, the real exchange rate must be stationary. This implies there cannot exist persistent deviations from real exchange equilibrium level only temporary ones.

¹⁷In this specification of the BS hypothesis, the danger of possible endogeneity could arise.

¹⁸Producer Price Index (PPI) is used for traded goods' prices.

specification of the BS hypothesis¹⁹:

$$\begin{aligned}
(\Delta p^{CEE} - \Delta p^{EA})_t &= \beta_1 \Delta e_t^{CEE} + \beta_2 [(1 - \alpha^{CEE})(\Delta a_T^{CEE} - \Delta a_N^{CEE})_t - \\
&- (1 - \alpha^{EA})(\Delta a_T^{EA} - \Delta a_N^{EA})_t] + \beta_3 [(1 - \alpha^{CEE})(\Delta w_T^{CEE} - \Delta w_N^{CEE})_t] + \varepsilon_t \quad (20)
\end{aligned}$$

where Δw_T and Δw_N denote the wage growth in the traded sector and in the non-traded sector, respectively.

According to last two columns in Tables 3 - 6, the size of the Balassa-Samuelson term is similar to one obtained from the first regression (the benchmark model) except for Slovakia. A percentage point increase in the productivity differential in Slovakia, the Czech Republic, Hungary and Poland is associated with an increase in the relative prices of about 1.3 %, 2.2 %, 2.9 % and 3.3 %, respectively. Again, in almost all cases we reject null hypothesis, i.e., the productivity growth differential has a positive impact on the relative price differential.

Recall that all these regressions contain 28 observations, which is, in fact, very short sample period. To resolve this short time span problem, we next employ a panel regression.

¹⁹Due to the fact that wages in the traded and non-traded sector move together in the Euro area, the term $[(1 - \alpha^{EA})(\Delta w_T^{EA} - \Delta w_N^{CEE})_t]$ will not reveal in equation (20).

Table 3. Individual estimates of Balassa-Samuelson effect for Slovakia

Country: SR	<u>Benchmark model:</u> (1)		<u>Benchmark model:</u> (1A)		PPP doesn't hold: (2)		PPP doesn't hold: (2A)		Wages: (3)		Wages: (3A)	
	price differential		price differential		price differential		price differential		price differential		price differential	
Nominal Exchange Rate (NER)	0.039 (7,28)		0.025 (1,14)		-		-		0.025 (4,71)		0.029 (1,51)	
Real Interest Rate (IR)	-		0.044 (0,70)		-		-0.003 (-0,72)		-		-0.014 (-0,24)	
Balassa-Samuelson Term (BS)	2.554 (3,12)		2.942 (2,96)		-0.085 (-0,52)		-0.172 (-0,84)		1.312 (2,11)		1.163 (1,32)	
Prices in Tradables (PT)	-		-		1.684 (48,36)		1.721 (27,61)		-		-	
Wages (W)	-		-		-		-		3.621 (2,86)		3.820 (2,50)	
Testing restriction on BS:												
	reject HO		reject HO		not reject HO		not reject HO		reject HO		not reject HO	
Sample period	1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4	
Number of observations	28		28		28		28		28		28	

Estimation method: Least Squares

Dependent variable: price differential (home versus foreign); First column provides independent variables according to chosen model

t-Statistics below coefficients

Testing restriction H0: BS = 0 against H1: BS > 0 on 5% significant level.

We reject H0 if t-Statistic > c where c is 95th percentile of the t-distribution with n-k degrees of freedom

* Regression includes the constant term

Table 4. Individual estimates of Balassa-Samuelson effect for Czech Republic

Country: CZ	<u>Benchmark model:</u> (1)		<u>Benchmark model:</u> (1A)		PPP doesn't hold: (2)		PPP doesn't hold: (2A)		Wages: (3)		Wages: (3A)	
	price differential		price differential		price differential		price differential		price differential		price differential	
Nominal Exchange Rate (NER)	0.044 (10,00)		0.050 (5,83)		-		-		0.046 (10,26)		0.041 (3,71)	
Real Interest Rate (IR)	-		-0.028 (-0,80)		-		-0.008 (-3,75)		-		0.027 (0,49)	
Balassa-Samuelson Term (BS)	1.930 (2,39)		1.857 (2,27)		0.050 (0,62)		-0.039 (-0,56)		2.210 (2,72)		2.397 (2,64)	
Prices in Tradables (PT)	-		-		1.637 (111,62)		1.687 (94,18)		-		-	
Wages (W)	-		-		-		-		1.628 (1,47)		2.312 (1,30)	
Testing restriction on BS:	reject HO		reject HO		not reject HO		not reject HO		reject HO		reject HO	
Sample period	1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4	
Number of observations	28		28		28		28		28		28	

Estimation method: Least Squares

Dependent variable: price differential (home versus foreign); First column provides independent variables according to chosen model

t-Statistics below coefficients

Testing restriction H0: BS = 0 against H1: BS > 0 on 5% significant level.

We reject H0 if t-Statistic > c where c is 95th percentile of the t-distribution with n-k degrees of freedom

* Regression includes the constant term

Table 5. Individual estimates of Balassa-Samuelson effect for Hungary

Country: HU	Benchmark model: (1)		Benchmark model: (1A)		PPP doesn't hold: (2)		PPP doesn't hold: (2A)		Wages: (3)		Wages: (3A)	
	price differential		price differential		price differential		price differential		price differential		price differential	
Nominal Exchange Rate (NER)	0.040 (7,89)		0.056 (1,74)		–		–		0.039 (7,54)		0.079 (2,26)	
Real Interest Rate (IR)	–		-0.052 (-0,49)		–		-0.0001 (-0,02)		–		-0.132 (-1,14)	
Balassa-Samuelson Term (BS)	2.821 (9,17)		2.606 (4,88)		0.439 (4,93)		0.437 (3,80)		2.898 (9,24)		2.397 (4,46)	
Prices in Tradables (PT)	–		–		0.933 (51,41)		0.934 (28,51)		–		–	
Wages (W)	–		–		–		–		-1.572 (-1,13)		-2.362 (-1,53)	
Testing restriction on BS:	reject HO		reject HO		reject HO		reject HO		reject HO		reject HO	
Sample period	1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4		1996:1-2002:4	
Number of observations	28		28		28		28		28		28	

Estimation method: Least Squares

Dependent variable: price differential (home versus foreign); First column provides independent variables according to chosen model

t-Statistics below coefficients

Testing restriction H0: BS = 0 against H1: BS > 0 on 5% significant level.

We reject H0 if t-Statistic > c where c is 95th percentile of the t-distribution with n-k degrees of freedom

* Regression includes the constant term

Table 6. Individual estimates of Balassa-Samuelson effect for Poland

Country: PL	Benchmark model:		Benchmark model:		PPP doesn't hold:		Wages:	
	(1)	(1A)	(2)	(2A)	(3)	(3A)	price differential	price differential
Nominal Exchange Rate (NER)	0.046 (2,06)	0.282 (2,24)	-	-	0.053 (2,28)	0.278 (1,88)		
Real Interest Rate (IR)	-	-0.193 (-1,90)	-	-0.011 (-1,71)	-	-0.188 (-1,54)		
Balassa-Samuelson Term (BS)	3.417 (10,32)	2.993 (7,74)	0.422 (1,75)	0.393 (1,68)	3.341 (9,85)	2.996 (7,51)		
Prices in Tradables (PT)	-	-	1.315 (15,34)	1.383 (15,10)	-	-		
Wages (W)	-	-	-	-	1.103 (1,01)	0.084 (0,06)		
Testing restriction on BS:	reject HO	reject HO	reject HO	not reject HO	reject HO	reject HO		
Sample period	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4		
Number of observations	28	28	28	28	28	28		

Estimation method: Least Squares

Dependent variable: price differential (home versus foreign); First column provides independent variables according to chosen model

t-Statistics below coefficients

Testing restriction H0: BS = 0 against H1: BS > 0 on 5% significant level.

We reject H0 if t-Statistic > c where c is 95th percentile of the t-distribution with n-k degrees of freedom

* Regression includes the constant term

Pooled estimates of BS term:

For the purposes explained in previous section, we have chosen fixed effects panel estimation. In this part of the paper, we extend the analysis of the previous section and estimate a model in which almost all coefficients are permitted to vary over the 4 CEE countries. Specifically, we consider three following regression equations, corresponding to "*standard*", "*full*" and "*extended*" specification of the BS hypothesis:

- "*standard*" specification:

$$(\Delta p^i - \Delta p^{EA})_t = \alpha_i + \beta_1 \Delta e_t^i + \beta_2 [(1 - \alpha^i)(\Delta a_T^i - \Delta a_N^i)_t - (1 - \alpha^{EA})(\Delta a_T^{EA} - \Delta a_N^{EA})_t] + \varepsilon_t^i \quad i = SR, CZ, HU, PL \quad (21)$$

where coefficient β_1 for the rate of change of the nominal exchange rate remains constant and the Balassa-Samuelson term β_2^i varies over countries.

- "*full*" specification:

$$(\Delta p^i - \Delta p^{EA})_t = \alpha_i + \beta_1 (\Delta p_T^i - \Delta p_T^{EA})_t + \beta_2 [(1 - \alpha^i)(\Delta a_T^i - \Delta a_N^i)_t - (1 - \alpha^{EA})(\Delta a_T^{EA} - \Delta a_N^{EA})_t] + \varepsilon_t^i \quad i = SR, CZ, HU, PL \quad (22)$$

where only the Balassa-Samuelson term alters among the countries.

- "*extended*" specification:

$$(\Delta p^i - \Delta p^{EA})_t = \alpha_i + \beta_1 \Delta e_t^i + \beta_2 [(1 - \alpha^i)(\Delta a_T^i - \Delta a_N^i)_t - (1 - \alpha^{EA})(\Delta a_T^{EA} - \Delta a_N^{EA})_t] + \beta_3 [(1 - \alpha^i)(\Delta w_T^i - \Delta w_N^i)_t] + \varepsilon_t^i \quad i = SR, CZ, HU, PL \quad (23)$$

where only the Balassa-Samuelson term stays country specific.

The results are reported in Table 7 behind this section. The first two columns provide the estimated coefficients for the benchmark model with standard assumptions. A percentage point increase in the productivity differential in Slovakia and Czech Republic is associated with an increase of about 1.7 % and 1.3 % in the relative price differential when compared to the Euro area. The results for Poland indicate the highest magnitude of the Balassa-Samuelson term among these 4 CEE countries of about 2 % per annum. On the other hand, the productivity growth differential in Hungary results only in 0.8 % higher relative prices.

The second two columns in Table 7 illustrate the estimates for the "*full*" Balassa-Samuelson model. Relaxing PPP for tradables results in a positive impact of the productivity growth differential on the relative price differential in Slovakia, Czech Republic and Poland. The Balassa-Samuelson effect in these three countries range from 0.4 % to 0.7 %. In contrast, a percentage point increase in the productivity differential in Hungary is associated with a decrease of about 0.1 % in relative prices when compared to the Euro area.

This is an interesting case and Hungary seems to behave differently if we employ the pooled analysis. A possible explanation can be found by examining the Baumol-Bowen effect among these accession countries. From Figure 4 we can see that the relative prices were rising with the growing relative productivity. But in a case of Hungary, the relative prices remain steady although the relative productivity is increasing. This empirical evidence suggests that the Baumol-Bowen effect in Hungary is not as substantial as among the other countries. Thus, we estimate the following regression equation for each accession country:

$$(\Delta p_t^N - \Delta p_t^T) = \text{const.} + \beta_1(\Delta a_t^T - \Delta a_t^N) + \varepsilon_t \quad (24)$$

where Δp^T and Δp^N denote the prices in the traded and non-traded sector. The Baumol-Bowen effect in Hungary is about 0.2 %, while in other CEE countries ranges from 1.3 % (in Poland) to 2.4 % (in Czech Republic).

According to last two columns in Table 7, the magnitude of the Balassa-Samuelson term in the "*extended*" model (in which we add the wage growth differential as an additional explanatory variable) is very similar to magnitude of the BS term in the benchmark model.

Then, the following null hypothesis is tested:

$$H_0 : \beta_2^{SR} = \beta_2^{CZ} = \beta_2^{HU} = \beta_2^{PL} = 0 \quad \text{against} \quad \text{any of } \beta_2^i > 0$$

for $i = SR, CZ, HU, PL$

where the alternative hypothesis represents the Balassa-Samuelson hypothesis (the productivity differential has a positive impact on relative price differential). As a result, for all specifications of the BS model we reject the null hypothesis, i.e., the productivity growth differential has a positive influence on the relative price differential and, thus, the Balassa-Samuelson effect seems to hold.

If we allow all the coefficients of equations (21)-(23) to remain constant over all countries, the test results will slightly change. Using standard assumptions and adding the wage growth differential variable to the regression equation will lead to the rejection of the null hypothesis and to strong support of the Balassa-Samuelson effect. In contrast, relaxing some of the assumptions for Balassa-Samuelson model (e.g., PPP does not hold for tradables) results in the acceptance of the null hypothesis and offers little evidence in favour of the Balassa-Samuelson hypothesis. These results are reported in Table 8 behind this section.

Finally, we summarize the individual country and pooled estimates for Slovakia, the Czech Republic, Hungary and Poland in Table 9. It is worth of noting that all the obtained estimates using the fixed effects panel estimation are smaller than the individual country estimates attained by least squares in the standard model and in the modification augmented by wages. In the specification of the Balassa-Samuelson model without assuming PPP for tradables, the pooled estimates are larger except for Hungary, where the Balassa-Samuelson effect is negative.

Table 9. The estimates of the Balassa-Samuelson effect
(percentage points per annum)

Country	Standard model		PPP doesn't hold in T		Adding wages	
	Individual	Pooled	Individual	Pooled	Individual	Pooled
Slovakia	2,5	1,7	0	0,4	1,3	1,3
Czech Republic	1,9	1,3	0	0,6	2,2	1,6
Hungary	2,8	0,8	0,4	-0,1	2,9	0,8
Poland	3,4	2,0	0,4	0,7	3,3	1,9

If we agree that estimates attained by fixed effects panel estimation are more trustworthy, then the productivity driven real appreciation ranges from 0.8 % (in Hungary) to 2 % (in Poland) under the standard assumptions. It suggests that the Balassa-Samuelson effect in these 4 CEE countries is not as sizeable as estimated by other authors²⁰.

²⁰Some estimates, e.g., by Simon and Kovacs (1998), Rother (2000), Halpern and Wyplosz (2001) show that productivity driven real appreciation is approximately 3 % per annum in a number of transition economies.

Table 7. Pooled estimates of Balassa-Samuelson effect

SR, CZ, HU, PL		Benchmark model: (1)*		Benchmark model: (1A)*		PPP doesn't hold: (2)*		PPP doesn't hold: (2A)*		Wages: (3)*		Wages: (3A)*	
		price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential
Nominal Exchange Rate (NER)		1.010 (13,37)	1.055 (14,45)	-	-	-	-	-	-	1.017 (11,89)	1.054 (12,42)	-	-
Real Interest Rate (IR)		-	-0.060 (-2,79)	-	-	-	-	-0.015 (-2,31)	-	-	-0.040 (-1,77)	-	-
Balassa-Samuelson Term (BS)													
BS_SR		1.693 (3,11)	1.140 (1,93)	0.381 (1,98)	0.294 (1,44)	0.381 (1,98)	0.294 (1,44)	0.381 (1,98)	0.294 (1,44)	1.287 (2,43)	1.002 (1,82)	1.002 (1,82)	1.002 (1,82)
BS_CZ		1.326 (1,60)	1.150 (1,45)	0.571 (4,20)	0.493 (3,99)	0.571 (4,20)	0.493 (3,99)	0.571 (4,20)	0.493 (3,99)	1.569 (2,08)	1.389 (1,82)	1.389 (1,82)	1.389 (1,82)
BS_HU		0.851 (4,31)	0.549 (2,56)	-0.157 (-1,16)	-0.220 (-1,44)	-0.157 (-1,16)	-0.220 (-1,44)	-0.157 (-1,16)	-0.220 (-1,44)	0.769 (3,28)	0.568 (2,26)	0.568 (2,26)	0.568 (2,26)
BS_PL		1.986 (6,06)	1.896 (5,90)	0.727 (7,12)	0.729 (7,32)	0.727 (7,12)	0.729 (7,32)	0.727 (7,12)	0.729 (7,32)	1.906 (6,34)	1.851 (6,13)	1.851 (6,13)	1.851 (6,13)
Prices in Tradables (PT)		-	-	1.182 (32,42)	1.196 (37,35)	1.182 (32,42)	1.196 (37,35)	1.182 (32,42)	1.196 (37,35)	-	-	-	-
Wages (W)		-	-	-	-	-	-	-	-	1.439 (3,13)	1.104 (2,34)	1.104 (2,34)	1.104 (2,34)
Testing restriction on BS:													
F-statistic		reject HO 13,24	reject HO 9,74	reject HO 23,05	reject HO 22,34	reject HO 23,05	reject HO 22,34	reject HO 23,05	reject HO 22,34	reject HO 12,09	reject HO 10,39	reject HO 10,39	reject HO 10,39
Sample period		1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4
Number of observations		112	112	112	112	112	112	112	112	112	112	112	112

Estimation method: Fixed effects panel estimation

Dependent variable: price differential (home versus foreign); First column provides independent variables according to chosen model

t-Statistics below (next to) coefficients

Testing restriction H0: BS_SR = BS_CZ = BS_HU = BS_PL = 0 on 5% significant level.

* Regression includes the constant term

$$F\text{-statistic is given by: } F = \frac{(R_U^2 - R_K^2) / s}{(1 - R_U^2) / (n - k)} \approx F_{1, n-k}$$

Table 8. Pooled estimates of Balassa-Samuelson effect II.

SR, CZ, HU, PL	Benchmark model: (1)*		Benchmark model: (1A)*		PPP doesn't hold: (2)*		PPP doesn't hold: (2A)*		Wages: (3)*	
	price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential	price differential
Nominal Exchange Rate (NER)	0.956 (11,54)	0.995 (11,88)	-	-	-	-	-	-	0.967 (10,85)	0.986 (10,84)
Real Interest Rate (IR)	-	-0.041 (-1,89)	-	-	-0.010 (-1,13)	-	-	-	-	-0.018 (-0,79)
Balassa-Samuelson Term (BS)	1.180 (5,90)	0.962 (4,29)	0.196 (1,380)	0.196 (1,380)	0.149 (1,02)	0.149 (1,02)	1.167 (5,40)	1.167 (5,40)	1.075 (4,54)	1.075 (4,54)
Prices in Tradables (PT)	-	-	1.189 (24,57)	1.189 (24,57)	1.196 (24,77)	1.196 (24,77)	-	-	-	-
Wages (W)	-	-	-	-	-	-	-	-	1.479 (3,13)	1.329 (2,67)
Testing restriction on BS:	reject HO	reject HO	not reject HO	not reject HO	not reject HO	not reject HO	reject HO	reject HO	reject HO	reject HO
Sample period	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4	1996:1-2002:4
Number of observations	112	112	112	112	112	112	112	112	112	112

Estimation method: Fixed effects panel estimation

Dependent variable: price differential (home versus foreign); First column provides independent variables according to chosen model

t-Statistics below coefficients

Testing restriction H0: BS = 0 against H1: BS > 0 on 5% significant level.

We reject H0 if t-Statistic > c where c is 95th percentile of the t-distribution with n-k degrees of freedom

* Regression includes the constant term

5 Conclusion

This paper presents a theoretically-based, econometric model of the real exchange rate appreciation in transition economies. For these purposes we have chosen four CEE economies: Slovakia, the Czech Republic, Hungary and Poland and compared them to the Euro area (EMU).

The key finding of this paper is the strong empirical evidence in favour of the Balassa-Samuelson effect in these four transition economies under the standard assumptions (1. capital is mobile, 2. labour is mobile, 3. PPP holds for tradable goods). According to our results, individual country estimates of the Balassa-Samuelson term are approximately 2.5 % per annum. Using panel estimation techniques, the magnitude of the Balassa-Samuelson effect is smaller. We find that the percentage point increase in the productivity growth differential will result in 1.7 % higher relative prices in Slovakia, 1.3 % higher relative prices in the Czech Republic, 0.8 % higher relative prices in Hungary and 2 % higher relative prices in Poland when compared to the Euro area.

Furthermore, relaxing one of the assumptions (3. PPP holds for tradable goods) lends a little support of the Balassa-Samuelson hypothesis, e.g., in Slovakia and Czech Republic, the productivity growth differential has no impact on the relative price differential. However, in the case of Hungary and Poland, the positive link still remains. In the cross-country context, if we allow a country specific Balassa-Samuelson term, we reject the null hypothesis. On the other hand, if the Balassa-Samuelson coefficients do not vary across counties, the null hypothesis is not rejected, i.e., the productivity differences have no influence on relative prices.

One important result of this paper is that EU candidate countries are expected to experience, and indeed, have experienced a substantial appreciation of the real exchange rate. Recent research on the appropriate monetary and exchange rate policies in EU accession countries discusses extensively the question of a possible conflict between the significant trend appreciation of the real exchange rate and the exchange and inflation rate criteria for EMU membership.

In the presence of the real exchange rate appreciation, the accession countries may face trade-off between exchange rate stability and the inflation target as required for the EMU membership. Since the real appreciation can be attained

through an appreciation of the nominal exchange rate, a higher inflation rate, or a combination both, different exchange rate regimes will imply different consequences for these policy criteria. In this respect, selecting the appropriate exchange rate arrangement before adopting the euro will be crucial for the process of the real and nominal convergence in transition economies.

According to our empirical investigation, the Balassa-Samuelson effect is "responsible" for an average annual rate of the real appreciation of around 2.5 %. Keeping the nominal exchange rate stable, as required for accession to EMU, could lead to an inflation rate 2.5 percentage point above that in the Euro area. Although these rates of inflation are not excessive, they violate the nominal inflation convergence criterion²¹ required for admission into EMU. On the other hand, if CEE countries allow their exchange rates to appreciate (as a reflection of their strong productivity growth as postulated by the Balassa-Samuelson effect), they will violate the stability of the exchange rate criterion²² for admission.

These analyses were done for the individual country estimates of the productivity driven real appreciation under the standard assumptions. Different scenarios will generate different outcomes. If the PPP assumption for tradables is relaxed, the magnitude of the Balassa-Samuelson effect is smaller and the violation of the inflation and exchange rate criteria does not have to occur.

In conclusion, it is important to note that the Balassa-Samuelson effect is an equilibrium phenomenon, not an undesirable transitory effect that ought to counteracted through policy operations. The real appreciation reflects the natural evolution of the economy, which has to be translated into relative prices changes.

²¹The annual inflation rate of EMU candidates must not exceed by more than 1.5 % the average of the three lower inflation countries in the Euro area.

²²Joining the exchange rate mechanism (ERM-II), i.e. limiting for at least two years exchange rate movements within a ± 15 % band around a central parity, is a necessary step to join the Euro currency area.

Appendix I.

The first-order conditions.

The representative firm faces the problem of maximizing profit expressed in terms of tradable goods :

$$\Pi_t = Y_t^T(L_t^T, K_t^T) + P_{REL}Y_t^N(L_t^N, K_t^N) - (W_t^T L_t^T + W_t^N L_t^N) - R_t(K_t^T + K_t^N) \quad (A1)$$

where W_t^i is nominal wage in the relevant sector, $i = T, N$ and R_t is the interest rate (determined in world financial market). Then the first-order conditions are:

$$\frac{\partial Y_t^T}{\partial K_t^T} = P_{REL} \frac{\partial Y_t^N}{\partial K_t^N} = R_t \quad (A2)$$

$$\frac{\partial Y_t^T}{\partial L_t^T} = W_t^T \quad (A3)$$

$$P_{REL} \frac{\partial Y_t^N}{\partial L_t^N} = W_t^N. \quad (A4)$$

"Domestic" Balassa-Samuelson hypothesis.

Solving for the capital-labour ratio in equation (10):

$$k_t^T - l_t^T = \frac{\log(1 - \gamma) + a_t^T - r_t}{\gamma} \quad (A5)$$

$$k_t^N - l_t^N = \frac{p_{REL} + \log(1 - \delta) + a_t^N - r_t}{\delta} \quad (A6)$$

and substituting them in the wage equation, i.e. $w_t^T = w_t^N$, we obtain the following expression for relative price:

$$\begin{aligned} p_{REL} = \{ & \delta[\log\gamma + \frac{1-\gamma}{\gamma}\log(1-\gamma) - \log\delta - \frac{1-\delta}{\delta}\log(1-\delta) + r_t(\frac{1-\delta}{\delta} - \frac{1-\gamma}{\gamma})] \} + \\ & + \frac{\delta}{\gamma}a_t^T - a_t^N \end{aligned} \quad (A7)$$

and by replacing the term in " $\{\}$ " brackets by constant term c , we obtain equation (13).

The alternative specification is obtained by calculating capital-labour ratio in equations (11), (12):

$$k_t^T - l_t^T = \frac{1}{1-\gamma}(w_t^T - \log\gamma - a_t^T) \quad (A8)$$

$$k_t^N - l_t^N = \frac{1}{1-\delta}(w_t^N - p_{REL} - \log\delta - a_t^N) \quad (\text{A9})$$

and substituting them in equation (10) we obtain:

$$\begin{aligned} p_{REL} = & \{(1-\delta)[\log(1-\gamma) + \frac{\gamma}{1-\gamma}\log\gamma - \log(1-\delta) - \frac{\delta}{1-\delta}\log\delta]\} + \\ & + \frac{1-\delta}{1-\gamma}a_t^T - a_t^N - (1-\delta)(w_t^T - w_t^N) + (\frac{1-\delta}{1-\gamma}w_t^T - w_t^N) \end{aligned} \quad (\text{A10})$$

where the last term disappears due to the fact that nominal wages weighted by labour intensities are proportional. Then by replacing the term in "}" brackets by constant term c , and $\tilde{\delta} \equiv 1-\delta$, resp. $\tilde{\gamma} \equiv 1-\gamma$, we obtain equation (15).

Appendix II.

Economies and periods covered

The panel data covers 4 countries (Slovakia, the Czech Republic, Hungary and Poland) and it is compared to the Euro area (EMU). The dataset was available from 1995:Q1 to 2002:Q4. All variables are expressed as logarithms of corresponding indices (1995=100).

Variable definitions.

real effective exchange rates: Currency Conversions/Real Effective Exchange Rate/Total; source: OECD MEI

nominal exchange rates: of domestic currency against the euro; source: National Central Banks, IFS

real interest rates: Interest Rates/3-mth or 90-day rates; source: OECD MEI

total CPI: Consumer Price Index/All items/Total; source: OECD MEI

non-tradable prices: Consumer Price Index/Services/Total; source: OECD MEI

tradable prices: Producer Price Index/Industry aggregates/Manufactured products/Total; source: OECD MEI

wages in traded sector: Labour compensation/Earnings/Manufacturing/Monthly; source: OECD MEI

wages in non-traded sector: Labour compensation in services; source: Eurostat, Slovak Academy of Sciences (SAV)

productivity in traded sector: TFP/TFP by economic activities/Manufacturing/Total; source: OECD ISD

productivity in non-traded sector: TFP/TFP by economic activities/Services/Total and TFP/TFP by economic activities/Construction/Total; the weights being specific to size of sectoral value added; source: OECD ISD

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Title: Estimating the Impact of the Balassa-Samuelson Effect in Transition Economies

Reihe Ökonomie / Economics Series 140

Editor: Robert M. Kunst (Econometrics)

Associate Editors: Walter Fisher (Macroeconomics), Klaus Ritzberger (Microeconomics)

ISSN: 1605-7996

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